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The generic identity for Melia excelsa Jack

By M. JACOBS

Foundation Flora Malesiana, Leyden

FROM THE FIRST, botanists have not felt quite satisfied with the taxonomic position of *Melia excelsa* Jack. De Jussieu excluded *Melia excelsa* (without mentioning an author's name) from *Melia,* referring it to *Hartighsea* (Mém. Mus. Hist. Nat. Paris 19: 220. 1830). Under this genus it became confused with *Dysoxylum excelsum* Bl.; this species was placed in *Hartighsea* by De Jussieu, but was later referred again to *Dysoxylum.* Miquel placed it, with doubt, in *Dysoxylum* (Ann. Mus. Bot. Lugd.-Bat. 4: 21. 1868). Hiern, in Hooker's Flora of British India, had it still under *Melia,* with its relative *M. azadirachta,* but King expressed his doubts soon after (J. As. Soc. Beng. 64, ii: 20. 1895) and his view was shared by Corner (1939) and by Merrill (1952).

When F. H. Hildebrand, in the course of his identification work in the Rijksherbarium at Leyden, came across this problem, he suggested that *Melia excelsa* might belong to *Azadirachta; Melia* and *Azadirachta* are allied and together form in the *Meliaceae-Melioideae* the tribe of the *Melieae.*

The genus *Azadirachta* was established by De Jussieu in 1830, with *Melia azadirachta* L. as the only species, which he named *Azadirachta indica* Juss. A second species, *A. integrifoliola,* was described by Merrill in 1909 from the Philippines. Harms, in the second edition of the Pflanzenfamilien, gave a good description of both genera, with many details. A few additional remarks on certain features may be made here.

A character particular to *Azadirachta,* which was known to Endert and other foresters, but, as far as I know, not yet mentioned in literature, are the glands on the petiole base. In *Azadirachta* there are two pairs of glands. They are not always all or fully developed, but if they are, there is one pair of orbicular glands, and, below, another pair of linear glands (fig. a). The glands are rather deeply sunk, and in the herbarium it is sometimes difficult to see them all; they are probably more conspicuous in

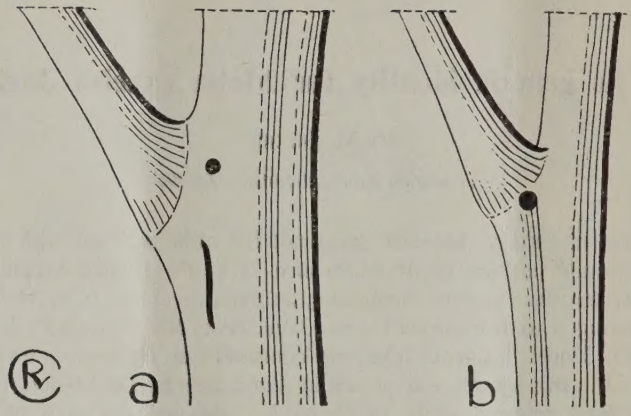

Fig. a, Glands at the petiole base of *Azadirachta excelsa* (Jack) Jacobs. b, The same of *Melia azedarach* L., both × 3 (a from *Cuadra A 904*, b from *bb 15142*).

living material. It is often discernable that they exude a blackish resinous sap. In *Melia* the glands are mostly lacking and obscure; if they are present, then there is only one pair, orbicular in shape (fig. b).

Another distinguishing character is the appearance of the style. In *Melia* it is twice as thick as in *Azadirachta,* approximately ½ against ¼ mm. In both genera the stigma forms a sort of crown. In *Melia* this is as wide as the style and is 4–6-lobed (fig. e). In *Azadirachta* it is about twice as wide as the style and 3-lobed, and the base of the crown is formed by a whitish-coloured ring (fig. c-d).

In *Melia* the innovations are densely covered with stellate hairs; in *Azadirachta* they are glabrous but the youngest parts are covered with a sort of resinous wax-like substance, which later breaks up into small scale-like flakes, persistent for some time, especially towards the base of the petiole.

There might be another difference between the genera, since most *Melias* are deciduous, whereas the *Azadirachta* species are known to be evergreen, even in the driest regions.

Here follows a summary of the most striking characters to distinguish the genera from one another.

Leaves 2–3 times pinnate. Innovations stellate-hairy. Base of the petiole occasionally with one pair of sunken orbicular

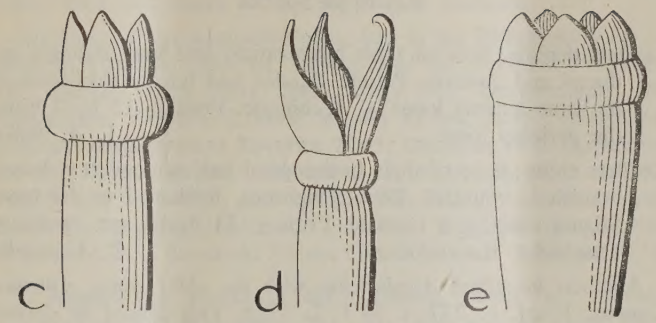

Fig. c, Stigma of *Azadirachta excelsa* (Jack) Jacobs. d, The same of *A. indica* Juss. e, The same of *Melia azedarach* L., all × 30 (c from *Agama 9970*, d from *Demandt 619*, e from *De Vriese & Teijsmann s.n.*).

glands. Inflorescence shorter than the leaves. Ovary 4–8-locular, in each locule 2 ovules, serially. Style thick, stigma 4–6-lobed. Drupe with thick bony endocarp, 3–8 locules, and as many seeds ..... *Melia*

Leaves simply pinnate. Innovations glabrous. Base of the petiole mostly with 1 pair of orbicular glands and 1 pair of elongate glands below these. Inflorescence about as long as the leaves. Ovary 3-locular, in each locule 2 ovules, collaterally. Style slender, stigma on a whitish ring, 3-lobed. Drupe with thin endocarp, 1 locule and 1 seed .... *Azadirachta*

Melia excelsa Jack, originally described from Penang, Malaya, has been very inadequately known for a long time, until Corner revisited the place and located the big old trees from which, to all probability, Jack had obtained his type material. Verification with Jack's type specimen, distributed by Wallich under number 1253 b (not B) was done at Kew by Airy Shaw, as Merrill reported (1952). Corner's excellent description agrees perfectly with the material in the Rijksherbarium under the name *Melia excelsa,* from Borneo, Sumatra, etc., and from the Philippines under the name *Azadirachta integrifoliola.* Merrill, the author of this species, reduced it himself in 1952 to *Melia excelsa.*

From Corner's description and from our material, the conclusion must be drawn that *Melia excelsa* Jack actually belongs to *Azadirachta.* Since *A. integrifoliola* has been reduced to *A. excelsa,* this is again the second species in this genus.

Key to the Species

Leaflets dentate; base of their basiscopical half very strongly reduced and cuneate. Petiole slender and hardly thickened at the base. Stigma lobes ± ¼ connate. Fruit ± 15 by 7 mm., the pericarp loose ..... 1. *A. indica*

Leaflets entire; base of their basiscopical half somewhat reduced, acutish to rounded. Petiole vigorous, thickened at the base. Stigma lobes ± ½ connate. Fruit ± 21 by 18 mm., pericarp attached to the endocarp ..... 2. *A. excelsa*

Adelbert identified *Azadirachta* with the older genus *Antelaea* Gaertn., Fruct. 1: 277, t. 58 f. 2. 1788. This cannot be correct as the fruit of *Antelaea* is described and depicted by Gaertner with 3 locules and 3 seeds, and there seems no reason whatever to reject the ingenious interpretation by Hallier f., who referred *Antelaea* to *Melia composita* Willd. (Rec. Trav. Bot. Néerl. 15: 33. 1918). According to Hiern (in Hook. f., Fl. Br. Ind. 1: 545. 1875) the correct name for *M. composita* Willd. (1799) is *M. dubia* Cav. (1789). Gaertner's fruit could not be found in the Rijksherbarium carpologica.

AZADIRACHTA

Azadirachta A. Juss., Mém. Mus. Hist. Nat. Paris 19: 220. 1830; C. DC., Monogr. Phan. 1: 459. 1878; Harms in E. & P., Pfl. Fam. iii, 4: 288. 1897; ed. 2, 19b1: 102. 1940.—*Antelaea* (non Gaertn.) Adelb., Blumea 6: 315. June 1948; in Backer, Bekn. Fl. Java (em. ed.) 7A: fam. 148 p. 10. Sept. 1948.

1. **Azadirachta indica** A. Juss., Mém. Mus. Hist. Nat. Paris 19: 220, t. 2 f. 5. 1830; C. DC., l.c. t. 6 f. 10; Harms, l.c. f. 160 M-S. 1897; l.c. f. 26 M-S. 1940.—*Melia azadirachta* L., Sp. Pl. 385. 1753.—*Melia indica* (A. Juss.) Brandis, For. Fl. NW. & C. India 67. 1874.—*Antelaea azadirachta* (L.) Adelb., l.c.

Distribution.—Native in Upper Burma (Brandis, Ind. Trees 139. 1906); cultivated throughout India, NW. to the River Sutlej, Ceylon, Indo-Chinese peninsula (not in Malaya), E. Java (incl. also Madura I.) to Sumbawa.

Uses.—This important tree is held sacred by Hindus; the fine wood is appreciated for the making of idols, for furniture and construction. The sap is drunk as a medicinal beverage. The oil extracted from the fruits is used medicinally, for dyeing, and for

lighting purposes. The gum comes not far behind Gum Arabic in value. Bark and leaves are also applied in medicine.

Specimens (only numbered ones, and in the Rijksherbarium).—India: d'Alleizette 1172; ed. Hohenacker 765; Perrottet 90; Wight 407. Burma: Kurz 2041. Siam: Kerr 542; Zimmermann 100. Indo-China: Pierre 872. Java: Backer 52 and 36337; Blume 94; Boschbouwproefstation Ja-series 2255; Demandt 619; Hochreutiner Pl. Bogor. Exsicc. 140 and 141; Koorders 4700, 14570, 14836, 14837, 14838, and 14912; Van der Meer & Den Hoed 2053; Pl. Junghuhnianae ined. 223. Bali: Boschbouwproefstation bb-series 13267. Lombok: Elbert 684. Sumbawa: Zollinger 3378.

2. **Azadirachta excelsa** (Jack) Jacobs, comb. nov.—*Melia excelsa* Jack, Mal. Misc. 1, 1: 12. 1820; Corner, Gard. Bull. S.S. 10: 263, f. 1–2, 1939; Merr. J. Arn. Arb. 33; 235. 1952.—*A. integrifoliola* Merr., Philip. J. Sc. 4: Bot. 272. 1909.

Distribution.—Sumatra, Malaya, Borneo, Philippines, Aru Islands, New Guinea.

Uses.—In Malaya as well as in Borneo the timber is valued for house-building; in Malaya the young shoots are eaten as a vegetable.

Specimens (only numbered ones, and in the Rijksherbarium).—Sumatra: Boschbouwproefstation bb-series, 23552, 23666, and 31664. Borneo: Agama 9227 and BNB 9970; Angian BNB 10489; Arumpod A 1715; Asah Anak Unyong BRUN 3123; Ashton BRUN 889; bb-series 23990, 23991, 24175, 26069, 26631, 26632, 27752, 29263, and 29414; Cenabre FB 29195 (in A; distributed under *Ailanthus philippinensis* Merr., a Simarubacea); Cuadra A 904; Harvey A 148. Palawan: Elmer 12638. Aru Is: bb 25388. New Guinea: Koster BW 4471; Mangold BW 2198; Schram BW 1787; Versteegh BW 701 and BW 3986.

The Genus Ceratopteris In Malaya

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DEVOL (1957) HAS REPORTED confusion between the two species *Ceratopteris thalictroides* (L.) Brong. and *Ceratopteris pteridoides* (Hook.) Hieronymus in the identification of Asian material. Previously it was believed that *Ceratopteris pteridoides* occurred only in America, where it is found from 30°N to 27°S in wet tropical and sub-tropical habitats. DeVol found that plants previously collected from Central China, Tonkin, Annam, Cochin China and Cambodia are in fact *Ceratopteris pteridoides*.

Benedict (1909) used annulus characters to distinguish species of *Ceratopteris*. Other authors have assumed that *Ceratopteris pteridoides* could be separated from *Ceratopteris thalictroides* by its very poorly developed annulus consisting of a few cells only, without a stomium. While this is true for American plants, DeVol found that plants of both species collected from Eastern Asia all had a well-developed annulus. Therefore it seems that this character is unreliable, and *Ceratopteris pteridoides* is better distinguished by (i) habit of growth with floating, not emergent sterile leaves, (ii) sterile leaves deltoid, simple, not repeatedly pinnate, and (iii) stipe widest at base of lamina and tapering downwards.

Unfortunately these features can be only used for Malayan herbarium material in those specimens which have sterile leaves, or in which the whole stipe is in a good state of preservation. Fern collectors, aware of the importance of sporangial characters in other groups, have tended to collect fertile material only. Other features were sought to distinguish the wealth of isolated fertile leaves. By comparison of plants* which definitely fell into the *Ceratopteris pteridoides* group sensu DeVol by virtue of their sterile leaf-type with those which fell into the *Ceratopteris thalictroides* group, two distinguishing features were found which can be applied to fertile leaves or plants which have been collected in isolation.

*In addition to Malaysian material some South American plants were examined for purposes of comparison.

Key to Malayan species of Ceratopteris

1. Sterile leaves deltoid, usually simple with broad basal lobes. Stipe broader above than below. Transitional leaves deeply pinnatifid. Fertile leaves very finely dissected, *ultimate segments webbed at their base, margin revolute only part-way to vein.* ..... **C. pteridoides.**

1. Sterile leaves pinnately divided. Stipe long and slender, usually broader below. Fertile leaves very finely dissected, ultimate lobes very slender and *not webbed at their base, margin revolute whole way to vein, all the lower surface being covered.* ..... **C. thalictroides.**

Ceratopteris pteridoides (Hook.) Hieronymus, Bot. Jahrb. 34: 561. 1905.

Sterile fronds simple, often divided into two or three lobes. Stipe 1.5–5.5 cm. long, broadened above. Lamina broadly deltoid, 2.0–3.0 by 2.5–4.0 cm. *Transitional fronds* pinnatifid, with about five pinnae. Pinnae subdivided into broad ultimate lobes, 0.2–0.6 by 1–0–2.0 cm. Ultimate lobes usually webbed at base. *Fertile fronds* three to four times subdivided. Adventitious buds often present. Stipe very long, 9.0–25 cm. Seven to ten pinnae. Lamina oblong to long deltoid, about 15.0 by 18.0 cm. Ultimate lobes wide, about 1.6 by 0.4 cm. *distinctly webbed at the base. Margin revolute only part way to vein, leaving a central uncovered portion.* Sporangia in one row. Annulus distinct, many celled. Spores 32, hyaline coat with distinctive ridged pattern.

Penang: Prai, a weed of rice-land (Md. Nur Nos. 6230 and 6240).

Singapore: Seletar (Ridley); Ang Mo Kio (Ridley).

Ceratopteris thalictroides (L.) Brogn., Bull. Sci. Soc. Philom. 1821: 186.

Sterile fronds pinnatifid two to three times divided. Stipes 4.0–10.0 cm. long, commonly broadest at the base, ultimate segments, blunt, oblong or trapezoid to triangular about 0.6 by 0.4 cm. Frond oblong. *Transitional fronds* variously divided, stipe about 13 cm., usually broader at the base than above, at least part of the margin revolute but sporangia very few or absent. Pinnae usually about eight. *Fertile fronds* variously divided, stipe about 14 cm. long, often broader at base. Ultimate segments very numerous,

often flagelliform to about 4 cm. long and 0.2 cm. broad. Margin revolute, covering 1–2 rows of large yellow sporangia. *No webbing at base of ultimate lobes. Whole of lower surface covered by revolute margin.* Annulus distinct, many-celled. Spores 32 or 16 with distinctive ridged pattern.

Kedah: Langkawi (C. Curtis).

Kelantan: Gong Kedah (Symington 37948), Kamposa (Ridley).

Trengganu: Bukit Toh Beng (Md. Haniff 15337).

Province Wellesley: Tanjong Bunga (C. Curtis).

Perak: Sungei Krian Estate (Spare 1783), Thaipeng (Wray 689); no. loc. (Scortechini), Grik (Burkill & Md. Haniff 12550), Bota Kiri, near Ipoh (Md. Shah 255), Parit Buntar, Krian (A.O., Krian).

Selangor: Bukit Bintang (Goodenough).

Malacca: Gambega Batu (Hervey).

Pahang: Telok Sisek, Kuantan (Henderson 22756), Kuala Brawas (Ridley 1509).

Singapore: Changi (Ridley 4227).

Results on examination of Herbarium material

On examination of the twenty-one sheets of *Ceratopteris* from Malaya available in the Singapore Herbarium, it was found that only four of these were clearly *Ceratopteris pteridoides*. These plants had been collected in Penang and Singapore. They all showed sporangia with a many-celled annulus, but the stomium was not always very distinct. There were always 32 spores in the sporangia.

The other sheets mentioned above proved to be *Ceratopteris thalictroides*. The sporangia, in all cases, had a distinct many-celled annulus, the stomium was often distinct, but the number of spores was either 32 or 16. Specimens with only 16 spores came from Langkawi, Tanjong Bunga, Ipoh, Krian and Malacca. All other specimens had sporangia with 32 spores only. As Benedict (1909) has remarked, an accurate count of the number of spores is rendered difficult by the fragile nature of the sporangial wall. In all cases counts were made on previously unruptured sporangia, by transferring them first to a slide and rupturing under a cover glass. In some cases all the sporangia of a given frond were found to be dehisced and a count was not possible. Records of 16 spores

in *Ceratopteris* are by no means unusual, in fact this number was recorded in Engler and Prantl's *Die Naturlichen Pflanzenfamilien.* However Benedict believes that this number is only found in the species he designates *C. deltoidea* Benedict, which falls in the *C. pteridoides* group sensu DeVol. However the Malayan specimens did not correspond to his species but were *Ceratopteris thalictroides,* their sterile leaves being oblong, not deltoid.

Examination of stipes

DeVol indicates that the kind of stipe is an useful feature in distinguishing *C. pteridoides* and *C. thalictroides.* In the former the stipe was broader above and tapering below, while in *C. thalictroides* the reverse was the case or the stipe was long and slender not tapering above. Examination of Malayan material indicated that while this feature was reliable for sterile and most transitional fronds it was not usable for fertile fronds. Measurements of the width of the stipe in sterile, transitional and fertile fronds were made at the base of the fronds and just below the point of emergence of the lowest part of the lamina. Ratios of:—

$$\frac{\text{width of stipe below}}{\text{width of stipe above}}$$ were calculated.

In the sterile fronds of *C. pteridoides* this ratio was always less than 1.0, varying from 0.45 to 0.90; while in *C. thalictroides* it varied from 1.66 to 2.50; that is the base of the stipe was approximately twice the width of the top of the stipe. In the transitional fronds of *Ceratopteris pteridoides* the ratio varied from 0.55 to unity, while in *C. thalictroides* it varied from 1.00–4.50. In fertile fronds of *C. pteridoides* it varied from 0.66 to unity, while in *C. thalictroides* it was unity or above to 5.0. Detailed results are given below with the standard errors of the mean values.

Means of ratios $\frac{\text{width stipe below}}{\text{width stipe above}}$

	Sterile frond	Transitional frond	Fertile frond
C. pteridoides ..	0.64 ± 0.08	0.69 ± 0.19	0.89 ± 0.03
C. thalictroides ..	2.05 ± 0.24	2.25 ± 0.43	1.66 ± 0.03

Within the population of *C. pteridoides* and *C. thalictroides* in Malaya there is a significant different in the form of stipe, but for transitional fronds and fertile fronds in both species the ratio may approach unity in individual specimens.

Lengths of stipes

Measurements in cms. were made of the lengths of all complete stipes available. The results are given below.

	Sterile	Transitional	Fertile
C. pteridoides ..	1.9 ± 0.03	5.7 ± 0.55	18.4 ± 3.69
C. thalictroides ..	7.4 ± 0.97	13.4 ± 0.90	14.07 ± 1.02

The stipes of the sterile and transitional fronds of *C. pteridoides* were significantly shorter than those of *C. thalictroides*. The lengths of the stipes of the fertile fronds showed considerable variation in both species.

Ceratopteris thalictroides on Singapore Island

In 1959 Miss Elizabeth Periathamby* made a survey of the morphology, anatomy and distribution of water-ferns on Singapore Island. She found *Ceratopteris thalictroides* only at Yio Chu Kang and on the Jalan Tebal. She did not find *C. pteridoides* at any of the 318 ponds on Singapore Island which she visited.

The *Ceratopteris thalictroides* was found rooted along the margin and some distance inwards in *Eichornia crassipes* ponds and also in one fish-pond. Sterile fronds were in all cases pinnatifid with some of the pinnae lobed. The occurrence of buds was noted in the sinuses of the lobes and at the apices. Sterile fronds growing in pots of damp earth produced fronds which were not always pinnatifid, some were irregularly lobed and some linear. Such strange fronds were never observed under field conditions.

The fertile fronds also produced adventitious buds covered by a small scale. Sterile fronds were formed on burying these fronds in soil.

*Contribution to the Morphology, Anatomy and Distribution of the Water-Ferns in Singapore. Thesis B.Sc. (Honours) 1959.

All specimens of *Ceratopteris* collected in recent years in Singapore Island by the author have proved to be *C. thalictroides,* not *C. pteridoides.*

Conclusion

Ceratopteris pteridoides and *C. thalictroides* both occur in Malaya but the former has only been found in Penang and Singapore. While it is easiest to distinguish the two species on their habit and shape of sterile leaves, it is possible to distinguish fertile leaves by webbing at the base of the ultimate lobes, and by the degree of revolution of the margin. In Malayan specimens of *C. pteridoides* the annulus is distinct and many-celled, but the stomium may be absent. The number of spores was always 32. In *C. thalictroides* there was a many-celled annulus often with a distinct stomium. The number of spores may be 16 or 32.

The width of the stipe above and below was only a reliable feature for sterile and transitional fronds. The lengths of these stipes was significantly shorter in *C. pteridoides.*

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Benedict, R. C. (1909) .. The genus Ceratopteris: a preliminary revision. Bull. Torrey. Bot. Club 36, 463–476.

DeVol, Charles E. (1957) .. The geographical distribution of *Ceratopteris pteridoides.* American Fern Journal, 47, 67–72.

Acknowledgements

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